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LITANI RIVER BASIN MANAGEMENT SUPPORT PROGRAM

AN ECONOMIC ASSESSMENT OF WATER USE AND WATER POLLUTION IN THE LITANI RIVER BASIN

May 2012
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FOREWORD

This economic Assessment of Water Use and Water Pollution in the Litani River Basin is mostly based on a report prepared by Dr William Jaegger from Oregon State University. Dr Jaegger was hired as short-term consultant by International Resources Group (IRG), the main contractor under the Litani River Basin Management Support (LRBMS) Program, a USAID-funded program in Lebanon (Contract EPP-I-00-04-00024-00 Task Order No.7) under the Integrated Water and Coastal Resources Management Indefinite Quantity Contract (IQC) II.

EXECUTIVE SUMMARY

PROGRAM BACKGROUND

The LRMBS Program is a four-year program to improve water management in the Litani River Basin in the Bekaa. It is undertaken by IRG, in cooperation with LRA, and is funded by USAID. The program began in October 2009 and has four components: Building institutional capacity, Water monitoring, Irrigation management and Risk management.

This study examines how water is used in the Litani River Basin (LRB) from an economic perspective. Economic aspects of water use can be divided into quantity (how water is allocated or used) and quality (water pollution). Both aspects are related to questions about the economic value of water, how its value is affected by problems such as water pollution and misallocation, and what might be done to use water more efficiently in the future.

ECONOMICS OF WATER ALLOCATION

The three main water uses that contribute directly (as distinct from indirect uses) to the economy are irrigation, hydropower, and urban use. Each of these represents an important, indeed essential, service providing food, energy, and household consumption and sanitation. Urban use also includes industrial uses. The level of use (in million cubic meters or MCM) and economic contribution is estimated as follows:

	Water use	Total value	Marginal value
Irrigated agriculture	200 MCM	$17 M	$0.07/m^3
Hydropower	250 MCM	$65 M	$0.26/m^3
Domestic/industrial use	25 MCM	$16 M	$0.65/m^3

These figures represent a summation based on average values and do not reflect their full life-sustaining role. Even with more detailed data, it would be difficult to draw conclusions about the efficiency of the existing allocation of water between domestic use, agricultural use and hydropower use, since each provides services that are “essential.” Agriculture provides food to the nation and employment in the interior of the country; electricity is essential to the functioning of cities and the economy; and domestic water use is a basic human need. Thus, decisions about the allocation of water among these particular competing uses involve economic as well as non-economic dimensions that are difficult to quantify and compare directly.

ECONOMICS OF WATER QUALITY

Water pollution, mainly from untreated domestic and industrial effluent, appears to pose the most serious current challenge to the LRB water resources and the watershed's overall environmental health. Despite widespread recognition of the problems, obstacles include: a) the incentives problems associated with "environmental externalities", b) the low incomes of many LRB residents, and c) existing institutional weaknesses and limitations.

A significant challenge to carrying out these tasks for the LRB is the dearth of data on even basic indicators of the quantities, qualities and values of the resources at issue. For example, water quality metrics are not regularly monitored. Nevertheless, there is ample evidence from studies elsewhere that water pollution from domestic and industrial effluent can be very costly to downstream water uses. Indeed, studies have estimated health damages from water pollution-related disease in the millions of dollars (e.g., New Delhi) or billions of dollars (Mexico), and increased illness from farming with polluted irrigation water has also been found to have significant ill health effects.

In general, the economic impacts from water pollution are estimated to reach as much as 1-2 % of the GDP of developing countries (for example in India and China). In Lebanon, the World Bank assessed in 2000 the annual burden of total pollution to be around 2.8 to 4% of GDP, with about 1% coming from water pollution[1]. Considering that the Litani River Basin covers about 20% of Lebanon's area and includes 10% of its population and, this represents today about $20-40M/year or $50-100/cap/year.

On the other hand, the cost of controlling water pollution by constructing municipal wastewater treatment plants have been estimated to range from $11-17 per person per year in levelized (annualized) costs (USAID 2003). About two-thirds of these costs are for operation and maintenance, or between $7 and $11 per person per year. In general, costs for a range of improvements in water and sanitation are estimated to vary from $0.30 to $22 per person per year depending on the service. Costs for solid waste collection and disposal are estimated to be $45-$50 per ton in Lebanon (SWEEPNET 2010), that is $14 per person per year.

A useful reference is a research by the World Health Organization (Hutton and Haller, 2004) which estimates the economic costs and benefits of a range of selected interventions to improve water and sanitation services for 17 WHO sub-regions, including the region for Lebanon. These estimates can be

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[1] World Bank. 2004. *Cost of Environmental Degradation – The Case of Lebanon and Tunisia*. Environmental Economics Series. Paper number 97.

viewed as providing a general indication of the size of both benefits and costs, and their ratios, which range from 5 to 20.

Remediation costs are clearly cheaper than pollution impacts but residents' willingness to pay is a consistent issue that often prevents funding and actual improvements. Indeed benefits from services such as water treatment, and solid waste management may be perceived to be significantly higher by outside observers than by the households living in the LRB.

People's willingness to pay for certain goods and services (nature's amenities or a pristine environment) tends to be low when people are struggling simply to feed and clothe their families, or when people do not directly suffer the impact of their actions or benefit from their mitigation (for example sewage treated or not being released downstream).

TOTAL ECONOMIC VALUE OF A WATERSHED

It is widely recognized that the value to society of a complex resource like a watershed is much greater than the values one could estimate for one or two specific services that are relatively easy to quantify. Thus, the concept of "total economic value" (TEV) has become an established and widely used framework to evaluate human-natural systems like watersheds. Some of the use and nonuse values that can be found to apply to a river basin or watershed like the LRB include services related to water storage, hydropower, agriculture, fish, ecosystems and recreational services. These categories represent the many ways in which a healthy watershed provides valuable ecosystem services in direct and indirect ways. Indeed, a study attempting to estimate upper and lower bounds for the value of these services in regions like the LRB, suggest an annual value of between $57 and $2.8 billion. The low end of the range of total values, $57 million, is exceeded by the calculations above for agriculture and hydropower alone. Water for people may be one of the more reliable ranges, indicating $12 to $98 million for the LRB. Indeed, this analysis suggests that the pollution and degradation that exists in the LRB watershed represent a loss of a significant share of these benefits and services.

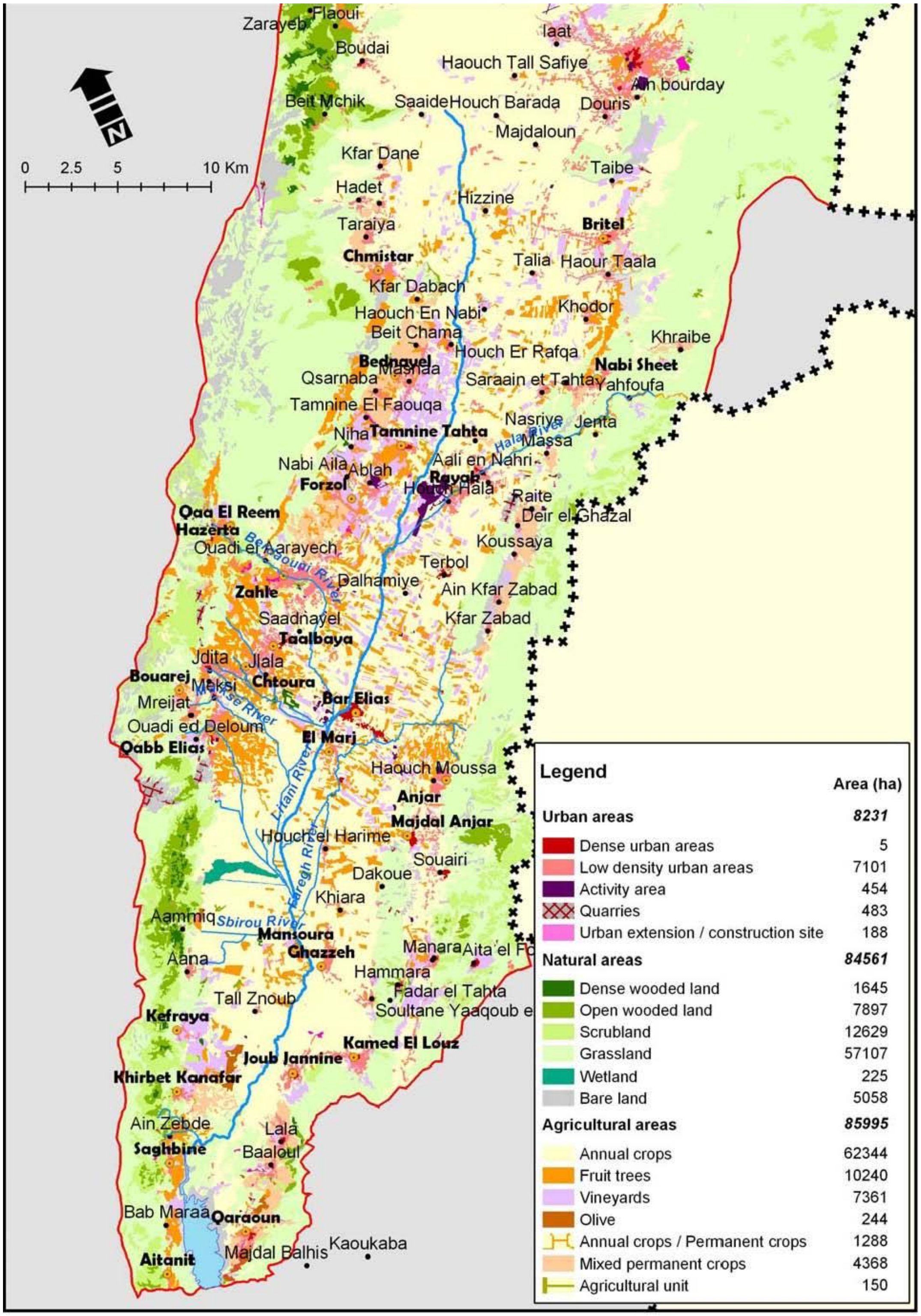
CONCLUSION

Given the importance of institutions to guide resource use, public investments, and monitoring and enforcement, as well as processes for anticipating changes in resource needs, and adjusting rules and public investments to respond to those changes, the institutional environment is critical for providing an "enabling environment" in which improvements in water resource management can be promoted. There is clear evidence that significant institutional obstacles exist in Lebanon and in the LRB in particular. The overall situation in the LRB appears to be one where a lack of effective institutions represents a sizable obstacle blocking a variety of policy recommendations that might otherwise promote more efficient use of water resources in the LRB.

Indeed, the deficient control of water pollution in the Litani River Basin is not in line with levels of remediation observed in other countries at a similar stage of economic development. The present analysis suggests that by the time income levels reach $15,000 per capita, countries have already made municipal wastewater treatment services available to about half their population. Moreover, as incomes rise from that level to $25,000 per capita, the share of the population served tends to rise to more than 90%. This pattern has been observed in countries as diverse as the US, Greece and western European countries. By contrast, the LRB, with an income per capital level of about $12,000 per capita provides wastewater treatment services to no more than 10% of its population. Thus, this suggests that Lebanon is "late" to make these kinds of investments in comparison to other countries at similar stages of growth in per capita income.

It is clear that the water resources in the Litani River Basin could be better managed to serve the interests of the people of Lebanon. Specific prescriptions require further careful and detailed analysis before choosing a course of action. The economic analysis presented here supports some general conclusions, and also points in directions needing further study. Overall, given the very low levels of wastewater treatment for domestic and industrial effluent, the available evidence suggests that the LRB's ecosystem services and "total economic value" have been significantly degraded in ways that adversely affect the local population, the nation as a whole, as well as their future prosperity.

The Litani River Basin



Source: BAMAS 2005.

ملخص تنفيذي

خلفية البرنامج

يستمر برنامج دعم ادارة حوض نهر الليطاني (LRBMS) الممول من الوكالة الامريكية للتنمية الدولية(USAID) لمدة اربع سنوات بهدف تطوير ادارة المياه في الحوض الاعلى (البقاع)، والذي تنفذه مجموعة الموارد الدولية IRG بالتعاون مع المصلحة الوطنية لنهر الليطاني LRA. بدأ تنفيذ المشروع في ايلول ٢٠٠٩ وهو يتألّف من اربعة اقسام: بناء القدرات، مراقبة المياه (نوعاً وكماً)، دعم ادارة مشاريع الري وإدارة المخاطر.

تبحث هذه الدراسة عن كيفية استخدام المياه في حوض نهر الليطاني من منظور اقتصادي. إن الجوانب الاقتصادية لاستخدام المياه يمكن تقسيمها للناحيتين التاليتين: الكمية (كيف يتم تخصيص المياه واستخدامها) والنوعية (تلوث المياه). يرتبط هذين الجانبين بتفسير القيمة الاقتصادية للمياه، وهذه القيمة تتأثر تأثيراً مباشراً بمشاكل مثل تلوث المياه وسوء الادارة والاستخدام وخصوصاً التركيز على سؤال ما يمكن فعله من اجل استخدام افضل للمياه في المستقبل.

اقتصاديات تخصيص المياه

تساهم استخدامات المياه الرئيسية الثلاثة في الاقتصاد بشكل مباشر وهي: الري، انتاج الطاقة الكهرمائية والاستخدامات المنزلية (وهناك اختلاف بالطبع عن الاستخدامات غير المباشرة). تمثل هذه الاستخدامات كل على حدى اهمية حياتية مطلقة بحد ذاتها، فمن جهة توفر هذه الخدمات الغذاء، الطاقة والاستخدامات المنزلية كافة كما وتشمل الاستخدامات الصناعية. يساهم مستوى الاستخدام (بالمليون متر مكعب) في الاقتصاد على الشكل التالي:

	استخدام المياه	القيمة الاجمالية	القيمة الحدية
الزراعات المروية	٢٠٠ مليون متر مكعب	١٧ مليون دولار	$0.07/ m^3$
الطاقة الكهرمائية	٢٥٠ مليون متر مكعب	٦٥ مليون دولار	$0.26/ m^3$
الاستخدامات المنزلية/ الصناعية	٢٥ مليون متر مكعب	١٦ مليون دولار	$0.65/ m^3$

تمثل هذه الارقام الجمع على اساس متوسط القيم ولا تعكس الدور الكامل للمفاعيل الحياتية. حتى مع بيانات اكثر تفصيلا، فانه من الصعب التوصل إلى استنتاجات حول التخصيص الحالي لاستخدامات المياه ما بين الري، انتاج الطاقة الكهرمائية والاستخدامات المنزلية، فالزراعة تؤمن الغذاء للوطن وفرص العمل في المناطق الداخلية; الكهرباء هي مصدر الاقتصاد وحياة المدن; واستخدامات المياه المنزلية هي حاجة اساسية للانسان. وبالتالي، فان

القرارات حول تخصيص استخدامات المياه بين الجوانب المذكورة والمتنافسة منها على وجه التحديد تنطوي على ابعاداً اقتصادية فضلاً عن الابعاد الغير اقتصادية والتي يصعب قياسها للناحية الكمية كما ويصعب مقارنتها مباشرةً.

اقتصاديات نوعية المياه

تمثل مياه الصرف الصحي غير المعالجة وصرف المصانع الدور الاكبر في تفاقم مشكلة تلوث المياه في الحوض الاعلى لنهر الليطاني والتحدي الاخطر في المرحلة الراهنة للرقعة المائية وكامل الصحة البيئية.

بالرغم من الادراك الواسع لنطاق المشاكل، إلا انه هناك عقبات اضافية كالتالي: أ) مشاكل الحوافز مشتركة مع "العوامل البيئية الخارجية"، ب) الدخل المتدني لسكان الحوض، و ج) ضعف ومحدودية المؤسسات القائمة.

تلعب قلة البيانات عن المؤشرات الاساسية كالكميات والنوعية وقضايا قيم الموارد، تلعب التحدي الابرز لتنفيذ المهام المقررة في حوض نهر الليطاني، على سبيل المثال فإن جودة المياه لا يتم رصدها بانتظام. إلا انه، هناك ادلة وافرة من دراسات اخرى تشير الى ان تلوث المياه من الصرف المنزلي والصناعي ستكون مكلفة جداً لمستخدمي المياه عند المصب. بالواقع، الدراسات قدرت الكلفة المادية الناتجة عن تفاقم التلوث بملايين الدولارات (كما هو الحال في نيودلهي) او بلايين الدولارات (المكسيك)، كما ورصدت زيادة كبيرة في الامراض الناتجة عن الري بالمياه الملوثة حيث وجدت تأثيرات صحية كبيرة.

بشكل عام، تقدر الآثار الاقتصادية الناجمة عن تلوث المياه ما بين ١–٢% من الناتج المحلي الإجمالي للبلدان النامية (على سبيل المثال الهند والصين). في لبنان، قيّم البنك الدولي في العام ٢٠٠٠ إجمالي العبء الاقتصادي السنوي للتلوث بما يقارب 2.8–4% من الناتج المحلي الإجمالي، ١% بسبب المياه الملوثة. إن حوض نهر الليطاني يغطي حوالي ٢٠% من مساحة لبنان التي تضم ١٠% من اجمالي السكان او بمعنى اوضح فإن كلفة التلوث تقارب ٢٠ إلى ٥٠ مليون دولار سنوياً او ٥٠ إلى ١٠٠ دولار للشخص الواحد في السنة.

من ناحية اخرى، تتراوح تكلفة السيطرة على مياه الصرف الصحي عن طريق بناء محطات المعالجة ما بين ١١إلى ١٧ دولار للشخص الواحد سنوياً وذلك كمعدل سنوي (الوكالة الامريكية للتنمية الدولية ٢٠٠٣)، حوالي ثلثي هذه التكاليف هي للتشغيل والصيانة، تقريباً ٧ إلى ١١ دولاراً سنوياً للشخص الواحد، بشكل عام، تتراوح كلفة تحسين خدمات المياه ما بين 0.3إلى ٢٢ دولاراً للشخص الواحد في السنة، كما وتقدر تكاليف جمع النفايات الصلبة ما بين ٤٥ الى ٥٠ دولاراً للطن الواحد في لبنان (SWEEPNET 2010)، وهذا ما يعني ١٤ دولاراً للشخص الواحد في السنة.

مرجع جيد لبحث اجرته منظمة الصحة العالمية (Hutton and Haller, 2004) حيث يقدر تكلفة الفوائد الاقتصادية من تحسين الامور المحددة العالقة الخاصة بالمياه والخدمات الصحية وذلك في ١٧ منطقة محددة من

قبل منظمة الصحة العالمية وتشمل لبنان. هذه التقديرات يمكن النظر اليها بشكل عام كمؤشر لجهتين الحجم والسعر، ونسبها، التي تتراوح ما بين ٥ و٢٠.

إن تكاليف معالجة المياه تبقى اقل بكثير من كلفة آثار التلوث وهذا ما لا يفهمه او يريدة سكان الحوض وتباعاً هذا ما يمنع التمويل من اجل التحسينات الفعلية. في الواقع، الفوائد من الخدمات مثل معالجة المياه، وإدارة النفايات الصلبة قد ينظر اليها من المراقب الذي لا يعيش في حوض النهر اعلى بكثير من الذين يقطنون داخل الحوض. إن استعداد الناس لدفع ثمن ملبسهم وطعام عيالهم اهم بالنسبة اليهم من معالجة ما ينتجون من نفايات (مثلاً، هم بكل بساطة يدعونها تذهب إلى الاسفل).

القيم الاقتصادية الاجمالية لمستجمعات المياه

هناك ادراك عام للقيم الاجتماعية المعقدة للمصادر الطبيعية مثلاً مستجمعات المياه تُقدر اكثر بكثير من قيمة خدمة او اثنين من تلك التقليدية السهلة. لذلك، فإن مفهوم الـ" القيمة الاقتصادية الاجمالية " اصبح ضمن إطار مستقر وتستخدم على نطاق واسع لتقييم النظم الطبيعية – الانسانية مثل مستجمعات المياه.

بعض القيم المستخدمة وغير المستخدمة التي يمكن ايجادها من اجل ان تطبق على احواض الانهر او مستجمعات المياه مثل حوض نهر الليطاني والتي تشمل الخدمات المتعلقة بتخزين المياه، الطاقة الكهرمائية، الزراعة ، الثروة السمكية، النظم الإيكولوجية وخدمات الترفيه، في دراستنا هذه كلها متوفرة من اجل تحقيق مثل هذا النظام. في الواقع، فهذه الدراسة تحاول ان تحدد قيّم الحدود القصوى والدنيا للخدمات المطروحة في منطقة شبيهة بحوض الليطاني حيث تشير إلى ان القيمة السنوية الوسطى تتراوح ما بين ٥٧ مليون و 2.8بليون دولار. الحدود الدنيا للقيم المذكورة هي ٥٧ مليون دولار، قد يتخطى المحسوب اعلاه لانتاج الطاقة الكهرمائية والزراعة لوحدهما. اما المياه للناس يمكن ان تكون اكثر واقعية، ما يؤشر من ١٢ إلى ٩٨ مليون دولار في حوض نهر الليطاني. في الواقع، فإن نتائج التحاليل التي تظهر تدهوراً بيئياً بسبب التلوث مستجمعات مياه حوض الليطاني تمثل خسارة حصة كبيرة من مزايا الخدمات.

الخلاصة

ينظر إلى وجود مؤسسات تعنى بترشيد وتوجيه استخام المياه بالاهمية البالغة، كذلك الامر بالنسبة إلى الاستثمارات العامة في هذا القطاع، وبالتالي فان عملها يشغل حيزاً من اجل توقع التغيرات وخصوصاً لجهة تزايد الحاجة إلى الموارد وقواعد تشغيل تلك الاستثمارات العامة وجعلها تتناساب مع تلك التغيرات، كذلك هناك اهمية بالغة للبيئة المؤسسية حيث يعتبر هذا امر حاسماً في توفير " البيئة التمكينية" والتي يمكن من خلالها تعزيز وتطوير الاداء في إدارة الموارد المائية.

كما هو معلوم فان لبنان يعاني من وجود عقبات مؤسسية كبيرة لا سيما على صعيد حوض نهر الليطاني، الذي يفتقد إلى وجود المؤسسات الفعالة والتي يمكنها زيادة كفاءة استخدام الموارد المائية.

في الواقع، فان مراقبة نوعية المياه في حوض نهر الليطاني لا تتناسب مع مستوى معالجة هذا الموضع في بلدان مماثلة لناحية النمو الاقتصادي. يوحي تحليل الدراسات ان وصول مستوى دخل الفرد إلى ١٥٠٠٠ دولار امريكي في السنة يؤدي الى رفع قدرة البلديات على معالجة الصرف الصحي لنصف السكان، كما ويرتفع إلى ٩٠% في حال ارتفاع دخل الفرد السنوي إلى ٢٥٠٠٠ دولار سنوياً، وهذا ما تم ملاحظته في بلدان مختلفة كالولايات المتحدة واليونان وبلدان اوروبا الغربية. لذلك كان لا بد من مقارنة هذه التحاليل مع ما هو الحال في الحوض الاعلى لنهر الليطاني، حيث يصل مستوى دخل الفرد السنوي إلى ١٢٠٠٠ دولار بينما خدمات الصرف الصحي لا تتجاوز ال١٠% من السكان المقيمين في الحوض. لذلك، يعتبر لبنان من البلدان المتأخرة، لجعل هذه الانواع من الاستثمارات تتساوى مع البلدان الاخرى، في مراحل مماثلة للنمو، بالنسبة لنصيب الفرد من الدخل.

من الواضح ان ادارة الموارد المائية يمكن ان تكون افضل في حوض نهر الليطاني، ما يخدم المصلحة العامة للبنانيين. ان بعض نتائج هذه الدراسة، بحاجة إلى مزيد من التحاليل المتأنية قبل الاعتماد عليها، وذلك من اجل تتحديد مسار العمل مع الاخذ بعين الاعتبار ان التحاليل الاقتصادية لهذه الدراسة تدعم بعض الاستنتاجات العامة.

في النهاية، يمكن اعتبار انه وبالنظر إلى المستويات المنخفضة جداً من معالجة مياه الصرف الصحي المنزلية ومياه الصرف الصناعية، تشير الادلة والمعطيات المتاحة إلى ان النظام الايكولوجي لحوض نهر الليطاني و "القيمة الاقتصادية الإجمالية" تدهورت بشكل كبير في الطرق التي تؤثر سلباً على السكان المحليين، وعلى كامل سكان الوطن، وكذلك سوف تؤثر على الازدهار في المستقبل.

1. INTRODUCTION

1.1. AUTHORIZATION

International Resources Group (IRG) was contracted by USAID/Lebanon (Contract EPP-I-00-04-00024-00 Task Order No. 7) under the Integrated Water and Coastal Resources Management Indefinite Quantity Contract (IQC) II to implement the Litani River Basin Management Support (LRBMS) Program. The period for performance of the contract is September 29, 2009 to September 30, 2013.

1.2. PROGRAM OBJECTIVES

The purpose of the LRBMS Program is to set the ground for improved, more efficient and sustainable basin management at the Litani river basin through provision of technical support to the Litani River Authority and implementation of limited small scale infrastructure activities.

The LRBMS program is part of USAID's increasing support for the water sector in Lebanon. The Litani River Basin suffers the fate of many river basins around the world: increasing demands compete for limited natural resources. Groundwater over-exploitation, deforestation and overgrazing, unplanned urban sprawl, untreated wastewater effluents, and unsustainable agricultural practices contribute to environmental degradation in the form of declining water and soil quality.

Solutions do exist to reverse these trends and establish sustainable management practices. The key to successfully implement such solutions requires applying the principles of Integrated Water Resources Management (IWRM) through a single river basin authority rather than multiple agencies responsible for different aspects of water management as is the case in many countries. Fortunately, the existence of the Litani River Authority (LRA) provides a unique platform to become such an IWRM river basin authority that will mobilize stakeholders in the river basin and address these challenges in an integrated manner.

Successful implementation of LRBMS will prepare the LRA to assume the role of an integrated river basin authority upon the removal of the present legal constraints.

1.3. PROGRAM COMPONENTS

LRBMS works with national and regional institutions and stakeholders to set the ground for improved, more efficient and sustainable basin management at the Litani River basin. The LRBMS technical assistance team provides technical services and related resources to LRA in order to improve their planning and operational performance and equip them with the necessary resources for improved river basin management.

To achieve the program objectives, LRBMS undertakes activities grouped under the following four components:

1) Building Capacity of LRA towards Integrated River Basin Management
2) Long Term Water Monitoring of the Litani River
3) Integrated Irrigation Management with two sub-components:
    a. Participatory Agriculture Extension Program: implemented under a Pilot Area: West Bekaa Irrigation Management Project
    b. Machghara Plain Irrigation Plan
4) Risk Management which with two sub-components:
    a. Qaraoun Dam Monitoring System
    b. Litani River Flood Management Model

1.4.PURPOSE OF THE REPORT

The goal of this report is to provide economic perspectives and observations on the current and future water pollution and allocation problems facing the Litani River Basin (LRB) in Lebanon. An economic analysis can, in principle, illuminate these issues in a number of ways. First, it can provide quantitative measures of the value of resources and, in particular, the foregone value, or lost net benefit, when resources are misallocated, wasted or degraded. When measured in common monetary units, these metrics provide a way to distinguish between high-cost and low-cost water-related problems. These kinds of measures of social cost, or foregone net benefits, can then, in principle, be used to evaluate a wide range of direct and indirect benefits from water such as irrigation, recreation or ecosystem services.

Second, economics provides a conceptual framework and a vantage point from which to identify the sources or causes of resource misallocation, misuse or degradation. By indicating how incentive incompatibilities, externalities, or free-rider problems have caused individuals' choices to be odds with the interests of society as a whole, economics can provide powerful insights into the causes of environmental and natural resource conflicts and crises.

Third, economics can provide some insights into potential solutions to the market and institutional failures that have resulted in wasted and degraded resources, and compare the benefits and costs of these remedies.

Of course, economic analysis requires biophysical and economic data in order to determine the scale of the problem in physical, quantitative terms, as well as sufficient economic information to translate these scale metrics into the economics of costs and benefits.

A significant challenge to carrying out these tasks for the LRB is the dearth of data on even basic indicators of the quantities, qualities and values of the resources at issue. For example, there appear to be no reliable data on trends in groundwater levels in recent years – not even from one regularly monitored well. Water quality metrics such as the concentrations of contaminants are not regularly monitored, and furthermore it would be extremely difficult to attribute negative effects on health, morbidity, mortality, or agricultural productivity or value-added to these contaminants. Nevertheless, there may be indirect ways that general observations and inferences can be made based on the information that is available.

The economic aspects of water use in the LRB can be divided into those involving quantity (how water is allocated or used) and quality (water pollution). Both aspects are addressed below in an effort to summarize what can be said about the economic value of water, how its value is affected by problems such as water pollution and misallocation, and what might be done to use water more efficiently in the future.

1.5. CONTENT OF THE REPORT

The economics of water allocation and use is discussed in section II; this is followed by a look at water quality in section III. Section IV broadens the discussion to include "total economic value" at the watershed level, and section V focuses on the relationship between total economic value and economic development. The role of institutions, broadly defined, is the focus of section VI. Some concluding comments are presented in the final section.

2. WATER USE AND EFFICIENCY

Questions about the economics of water use might include the following: How much value does Lebanon get from the water in the Litani Basin? Is water in the LRB being put to its highest value uses? Could more "value" (including social, environmental and other indirect sources of value) be had by moving water from one use to a different use? Is water, as currently allocated, being used wastefully? These are just some of the some of the questions that an economic analysis might want to address.

To begin with, it is useful to look at the different ways that water is valuable in its current uses. The "total value" of water to the people of Lebanon is derived from its numerous direct and indirect beneficial uses:

- Use for urban residential, industrial and commercial purposes
- Hydropower production
- Irrigated agriculture
- Waste disposal services (taking waste away and, to some extent, assimilating it)
- Recreational purposes
- Ecosystem services
- Aesthetics.

A comprehensive assessment of all these uses would require detailed data that are simply not available and is beyond the scope of the current study.[2] Nevertheless, based on some of the information that is available, some observations and quantitative measures of water's value can be generated directly and indirectly. In the subsections below, existing data and other sources of information are utilized to derive some summary observations about the economic value of water in its main areas of use (agriculture, hydropower, and urban consumption), along with some observations about water use efficiency and future water demand.

[2] Several recent analyses have been conducted that provide background and insights that complement the analysis presented here. At the national level, two World Bank reports provide useful information (World Bank 2003, 2010). Specific to the LRB, there is the ELARD (2011) UNDP report, SPI-Water (2007) and BAMAS (2005), among other studies referenced below.

2.1. AGRICULTURE

Irrigation of agriculture is one use of water that a) directly benefits local residents, b) can be encouraged or discouraged by policy and by investments in infrastructure, and c) may involve efficient or inefficient/wasteful use of water on a per hectare basis.

A central question is how much value, or value-added, water generates when it is used for irrigation. There are several methods that could be used to answer this question. One approach involves compiling detailed data on farm inputs, costs of production, revenue from crops produced, and hence net revenue or profits. However, there is an alternative approach that is both simpler and more reliable; it involves using market prices for land sales or land rental rates, and making inferences about the additional value typically generated when water is available for irrigation of those lands. If one compares the land rental rates for land with, and without, irrigation water, the difference in these two values (e.g., the price paid to use a hectare of land for one year) will reflect the additional value attributable to the availability of water for farming. That is, it reflects what farmers are willing to pay for renting irrigated land as compared to renting non-irrigated land. This method is known as an "hedonic valuation" method. Because this method relies on land rental rates (where the value of the attributes of the land have been "capitalized" into the price), it is firmly grounded on the economic principle of "Ricardian rents", one of the most durable principles in economics.

Based on interviews with farmers and others individuals familiar with land rental markets (which appear to be quite active in the LRB), irrigated land frequently rents for $1,500/ha, although values range above and below this figure. For lands that do not have access to irrigation, the rental rate is lower, frequently $1000/ha, although rental rates here also vary according to the location, soil and other characteristics. Thus, the difference in value that can be attributed to the presence of irrigation water is $500 per hectare per year.

To complete our calculation of the value of water, we need to know the amount of water used. Water use, or the evapotranspiration (ET) of typical crops, is on the order of 7000 m^3/ha/crop (Mohammad Al Arab 2001). Lands that are double cropped will use 50% more than this amount but represent only a small portion of the area.With a value of $500 per hectare for irrigation water, this translates into a marginal value of water of about $0.07/$m^3$.

This calculation suggests a relatively high value for water in the LRB. Analyses using this same "hedonic valuation" method to value irrigation water in areas of the western United States that are fairly similar to the LRB, have estimated the value of irrigation water to be between $0.01/$m^3$ and $0.04/ m^3 (Jaeger and Mikesell, 2002; Boehlert and Jaeger, 2010). This suggests that the value of irrigation water in the LRB is 3 to 15 times higher than the value of irrigation water in the western USA. Other studies based on hedonic methods and surveys (contingent valuation) have estimated the range of average values for irrigation water to be between \$0.015 and \$0.075/m^3 (Aylward et al. 2010).

Generally speaking, higher per acre returns from using irrigation water can be due to lower costs, higher productivity, or higher crop prices. In the LRB a likely contributing factor, and perhaps the dominant factor, is the relative scarcity of good irrigated farmland in Lebanon relative to the size of the population demanding food. By contrast, there is a relative abundance of farmland in the western USA (relative to the population and demand for food). This relative scarcity of irrigation potential likely makes for high food prices and thus makes the value of irrigation water higher in the LRB compared to places like the western USA.

These estimates underscore the conclusion that allocating water to irrigation in the LRB is a high value use of water in terms of its potential: a) to generate net benefits, b) to provide food for the Lebanese people, and c) to provide jobs and income to a sizable number of Lebanese farmers. Indeed, irrigated lands are estimated to comprise 10,000 hectares for annual crop and 30,000 hectares of perennials in the LRB (IRG/USAID 2011). (An additional 40,000 hectares is estimated to produce winter wheat in the offseason as a rainfed crop.) Based on the water values estimated above, this represents a net benefit of \$11 million for the annual/summer crops and potentially another \$6 million to \$12 million for the value of irrigation water applied to trees and other perennial crops (which in general use less water per hectare). Thus, as a rough estimate is that irrigation water generates between \$17 million and \$23 million in net revenue or "value-added" in the LRB (see Table 1).

Table 1. Economic value of irrigation water currently used in the LRB

Type of irrigation	Hectares	Estimated value from irrigation
Summer crop rotations	15,000	\$ 7 million/year
Perennial crops	20,000	\$ 10million/year
TOTAL:	35,000	\$ 17 million/year

2.2. HYDROPOWER

Most of the waters in the LRB that escape evaporation, deep infiltration, or use in the upper basin for domestic, industrial, or irrigation purposes, pass below Lake Quaroun through a three-station hydropower cascade that is estimated to generate 1.9 kwh per cubic-meter of water. The estimated volume of water descending through these generation plants is estimated to be 250 – 300 million m^3 per year, which would generate between 475 and 570 gigawatt hours of energy. Given Lebanon's annual consumption of power in 2009 of 13.1 gigawatts[3], this represents about 4% of the country's current electricity demand.

The hydropower energy generated by these power plants is "sold" or transferred to the electric distribution utilities at a low "accounting price." However, in the analysis here we want to value this energy at its "replacement cost" (what it would cost to produce the electricity using other means such as natural gas or gas-oil generation). Those costs or values are $0.089 - $0.15/kwh (World Bank 2008). Applying those values to the power generated on the Litani River suggests a total value for the LRB hydropower operations of $43-$85 million annually.

2.3. DOMESTIC AND URBAN CONSUMPTION

Domestic and urban water use in Lebanon is estimated by the World Bank to be 150 liters/person/day for Lebanon (World Bank 2010). For the 375,000 people living in the LRB this

amounts to about 20 MCM/year (million cubic meters per year). Only a fraction of this water (perhaps less than 20% based on estimates in other urban centers) is "consumed" and removed from the hydrologic system. The majority of this water is returned to the groundwater and surface water system in the form of waste water. Water for urban and industrial use (aside from household use) is estimated to be 5 MCM/year. In terms of economic value, there is no doubt that the value of water for these uses, essential to any population center, is high. Putting a value on domestically consumed water can lead to misinterpretation (is the figure intended to reflect marginal value or average value?). Moreover, studies of the value, or willingness to pay, for domestic water supplies produce highly varying estimates. A recent survey of these studies across different countries found the average to be $0.59/m^3 for domestic/household use, and $0.86/m^3 for industrial use (Aylward et al., 2010). Applying these figures to the LRB suggests a total value of $16 million annually for domestic and industrial uses.

The three main water uses evaluated above contribute directly to the economy of the region and the nation. They represent important, indeed essential, services in that they provide food, energy, and water for household consumption and sanitation. In the table below we can see that the most value (derived directly) comes from hydropower which generates $65 million annually, followed by irrigated agriculture and domestic/industrial uses. These figures represent a summation based on average values and do not reflect their full life-sustaining role. Indeed, the marginal value per cubic-meter is found to be highest for water's domestic and industrial uses ($0.82/m^3), followed by hydropower and irrigation.

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[3] International Energy Agency (http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=LB)

Table 2. Major water uses: quantities and economic values

	Water use	Total Value	Marginal value
Irrigated agriculture:	200 MCM	$17 M	$0.07/m^3
Hydropower	250 MCM	$65 M	$0.26/m^3
Domestic/industrial use	25 MCM	$16 M	$0.65/m^3

2.4. EFFICIENCY

The question of whether water is being used efficiently in the LRB is a natural one to address as part of an economic assessment. Is the allocation of water among competing uses – such as between agriculture and hydropower -- "optimal" from the standpoint of producing the highest total value? And is the water allocated to any given use being used efficiently – is water being wasted, for example by irrigating poor quality lands when higher quality lands are available, or is water being passed through obsolete turbines that fail to maximize power generation?

Because of data limitations, answering these questions in specific terms poses significant long-term challenge for Lebanon. However, concerning the issue of efficiency of water use within a given type of use, there is some evidence to suggest that water could be conserved, for example, in irrigated agriculture. More specifically, there is evidence indicating that farmers who use sprinkler irrigation could switch to drip irrigation without significant increases in cost. Moreover, to the extent that farmers are more likely to over-irrigate their fields using sprinklers rather than drip, the adoption of drip irrigation may also reduce over-irrigation (see, for example, Mohammad Al Arab 2001; Karam 2012). Indeed, the Litani River Basin Management Support (LRBMS) project conducted trials with farmer involvement to grow potatoes using less water and less fertilizer. Some of the farmers were convinced by this experience that they could achieve the same yield, and higher profits, with reduced water and fertilizer application (Mahmood Khalifeh, personal communication, January 2012). Reductions in excessive application of water on some farms would make that scarce water available for use on other productive irrigable lands. These kinds of changes could be highly valuable. For example, if changes in farm practices could conserve 20% of water currently used in irrigation, this water could allow expansion in irrigated lands and provide for an additional $2 million of value-added in agriculture.

Even with detailed data, it would be difficult to draw conclusions about the efficiency of the allocation of water between domestic use, agricultural use and hydropower use. Each of these provides services that are to a large extent "essential." Agriculture provides food to the nation and employment in the interior of the country; electricity is essential to the functioning of cities and the economy; and domestic water use is a basic human need in all societies. Given the essential role of domestic water use, and the high priority for food production and employment in the interior of the country, if one of these three uses of water had to take a lower priority, the case could be made for relying on alternative sources of electricity (power plants). The counter-argument, of course, is that the value generated per cubic-meter of water for electricity generation is significantly higher than the already-high value in agriculture. Thus, decisions about the allocation of water among these particular competing uses involve economic as well as non-economic dimensions that are difficult to quantify and compare directly.

Lebanon faces rising demand for water, especially in the dry season. This raises questions about the potential for additional storage reservoirs to retain winter runoff for use in summer when water scarcity is highest. "The main contributing factors of the seasonal water imbalance are the very low water storage capacity, the high amount of water lost to the sea, the growing demand for water and the deficiency of the existing water networks" (World Bank 2010).[4] According to the World Bank, Lebanon's water storage capacity is well below levels in other Middle East and North African countries. Lebanon's dam capacity amounts to only 5 percent of total renewable water resources, compared to 56 percent in Tunisia and Morocco and almost 300 percent in Egypt (World Bank 2010). Site-specific detailed studies would be required to evaluate the net economic benefits of expanding Lebanon's water storage capacity.

Of course, groundwater is an important natural way to store water in the LRB, and this is a critically important resource for agriculture, domestic and industrial use. Indeed, in irrigation, groundwater provides 60% more of the total water applications than surface water, with the timing of these applications concentrated in summer when surface water flows are very low. There is wide agreement, but only anecdotal evidence, that groundwater resources in the LRB are being depleted, and that the groundwater levels are declining rapidly as a result. This phenomenon is not surprising: aquifers are particularly vulnerable to the "tragedy of the commons" problem for common-pool resources since it is so difficult to acquire information about the resource's use, recharge rate, and level of depletion.

[4] About 0.7 BCM of runoff rain water is currently lost to the sea every year (World Bank 2010).

3. WATER QUALITY

Poor water quality in the LRB has become a topic of concern in recent years, in large part because it is well know that little is done to control the constant flow of human and industrial waste into the Litani River system. Several studies have investigated these issues in the past decade. The results of these studies are summarized as follows:

"Domestic and industrial wastewater, solid waste, and agrochemicals are identified as sources of pollution in the Upper Litani Basin. … the most significant sources of contamination to surface and ground water are associated with the uncontrolled discharge of untreated wastewater along the Litani River and its tributaries, and the use of agrochemicals, especially nitrates. The highest levels of contamination along the river were observed within the mid-upper Litani basin where domestic wastewater from the largest communities is discharged into watercourses. Several chemical and biological indicators exhibited concentrations in the river water samples exceeding drinking, bathing, domestic, and irrigation water quality standards during the wet winter season. Evidently, the contamination levels increased during the dry summer season. However, Lake Qaraoun water quality improved during the summer mainly due to the fact that the levels of pollutants in the Lake are governed mostly by Lake dynamics (dilution, stratification, currents, sedimentation) and by the intermittency and low volume of flows that reach the lake during the dry season. Canal 900 water quality was found to be acceptable for irrigation under most conditions with only limited restrictions. Soil, sediment, and fish samples exhibited variable levels of heavy metals. … The health survey revealed that at least 6,150 recorded cases in 2004 can be related to waterborne illnesses in the basin. The majority of these cases were found in large communities that discharge untreated wastewater into the Litani River and its tributaries. … agrochemical application rates are generally high… High total and fecal coliform levels can be attributed to wastewater discharge practices in the area, including non-maintained septic tanks and open discharges." (BAMAS 2005)

And similarly:

"Current surface water quality status is characterized by a heavy load of organic material. Analysis showed the majority of water courses are severely affected from domestic wastewater discharge. This is evident from the concentration of organic matter, measured as chemical Oxygen Demand (COD) or Total Organic Carbon (TOC), and in the concentrations of ammonia. The content of heavy metals is not alarming, but still a cause for concern. Indicators showed that water samples from the Litani River and its tributaries exhibited concentrations exceeding drinking, bathing, domestic, and irrigation water quality standards level at the dry summer season. However, the water quality in Qaraoun Lake and in Canal 900 was found to be acceptable for irrigation under most conditions with only limited restrictions; High concentrations of Fecal Coliform, BOD, Nitrate, Ammonium, and phosphate which are registered mainly in highly populated and cultivated areas of Upper Litani RB. With the exception of Lead and Mercury, metal concentrations showed a pattern of lower concentrations. Groundwater sampling showed increase in nitrates level." (SPI-Water 2007).

Thus, there is no doubt that "pollution in the Litani River, the largest in Lebanon, has limited its use" (World Bank 2003). The dominant sources of pollution come from domestic and industrial effluent, as well as from dumping of solid waste. The estimates in Table 3 provide some indication of these sources and their scale. In addition to these figures for industrial effluent, between 15 and 20 million m^3 of wastewater is released in the basin. Detailed data are unavailable, however, as water quality in the Litani River is not monitored in a systematic way, although selective sampling of data was undertaken in 2005 (Doummar et al. 2009), and another sampling was undertaken in 2011 (ELARD/UNDP 2011).

About 90% of the wastewater generated in the Litani basin is not treated in a wastewater treatment plant (WWTP). Much of this is discharged through networks that eventually reach the Litani River. There are numerous planned WWTPs, with some of these projects experiencing significant delays. In some other cases WSWTPs have been built but are not operating, or not operating correctly. In at least two cases (Ferzol and Jeb Jannine), new WWTPs built with foreign assistance funds have yet to be utilized, apparently because municipalities have determined they are unable to pay for the costs of operation and maintenance.

The remainder of this section describes the economic incentives underlying the causes of water pollution; it also examines the costs of pollution, and the costs of pollution remedies, leading to a discussion of weighing benefits and costs of actions to reduce pollution.

Source: ELARD/UNDP 2011.

3.1. THE INCENTIVE PROBLEMS THAT GIVE RISE TO POLLUTION

From an economic perspective, water pollution is a straightforward example of a "negative externality" whereby an action by one person or group imposes a cost on another person or group – but the person or group taking the action does not consider those "external costs" when deciding whether or not to take the action. In the case of water pollution, individuals upstream simply release effluent into a river system without taking account of the costs this act has on individuals downstream who suffer damages from pollution. These damages may come in the form of health effects, productivity effects, or extra avoidance and adaptation costs, but nearly all of those costs affect individuals downstream, not those who are doing the polluting. The upstream actors have no incentive to undertake costly wastewater treatment because the benefits of that treatment to not accrue to them. This simple concept of an externality helps explain pollution problems of many kinds. It also can help us understand which types of remedies are likely to be relatively more or less effective.

Water pollution is high in the LRB, and three factors are central to the absence of strong interventions to remedy the situation, even though there is widespread recognition of the need for improvements. These three factors are: a) the nature of incentives problems associated with externalities, b) the relatively low incomes of most LRB residents, and c) existing institutional weaknesses and limitations.

Absence of Incentives: The first factor is the externality itself which, as just described, results in an absence of incentives for cities upstream to pay the cost of remedies such as wastewater treatment control. Instead, cities upstream have strong incentives to simply release raw sewage into the Litani River, despite its harmful effects on individuals downstream in other cities and in rural areas. In the absence of measures to introduce effective incentives or implement remedies, it cannot be expected that local governments will choose to pay for waste treatment themselves – because others suffer most of the consequences.

Low income: The second factor is the low income of most residents of the LRB, and the way that income affects the demand for specific kinds of goods and services. People's "willingness to pay" (WTP) for certain goods and services tends to be low when they are poor. This WTP rises with rising income, but the relationship differs for different kinds of goods and services. In some cases, individuals' WTP for specific kinds of goods and services may increase only after their incomes have risen beyond a certain level. For example, it is understandable that the very poor are less willing to pay for nature's amenities or a pristine environment when they are struggling simply to feed and clothe their families.

When it comes to water-related goods and services, there is ample evidence to suggest high social benefits – or high WTP – for *some* goods and services at a relatively low level of income, but not necessarily for others. A useful point of departure is research by the World Health Organization (Hutton and Haller, 2004) which estimates the economic costs and benefits of a range of selected interventions to improve water and sanitation services. The costs and benefits are evaluated at the global level, and for 17 WHO sub-regions, including the region for Lebanon. Table 4 indicates the five main interventions for Lebanon's WHO epidemiological sub-region. Predicted reductions in the incidence of diarrheal disease were calculated for each intervention based on predicted reductions; additional benefits estimated include time savings for reduced illness and convenient access to water, gains in productivity, and reduced health sector and patient costs.

Due to the general methodology of the WHO study and the region-wide basis for its estimates, we cannot interpret them in a precise way for the LRB. The estimates can, however, be viewed as providing a general indication of the size of both benefits and costs, and their ratio, for these particular kinds of water and sanitation improvements. Indeed, the results below in Table 4 are indicative of the estimates for all developing regions, where benefits exceed costs by a factor of 5 to 20 for all interventions.

Table 4. Estimated costs and benefits for Water and Sanitation Improvements in Lebanon

Intervention:	Annual cost per capita	Annual benefit per capita	Benefit-cost ratio	Benefit-cost ratio*
1. Halving portion of population without improved water sources:	$ 0.30	$ 4.09	$ 13.63	$ 1.60
2. Halving portion of population without improved water and improved sanitation facilities:§	$ 1.20	$ 15.26	$ 12.72	$ 2.20
3. Access for all to water and sanitation:§	$ 2.40	$ 36.50	$ 15.21	$ 2.88
4. Water disinfected at point of use for all, in addition to goals 1-3.	$ 3.00	$ 63.21	$ 21.07	$ 3.05
5. Access for all to regulated piped water supply and sewage connection to their houses:	$ 22.20	$ 113.66	$ 5.12	$ 0.93

Source: Hutton and Haller, 2004.

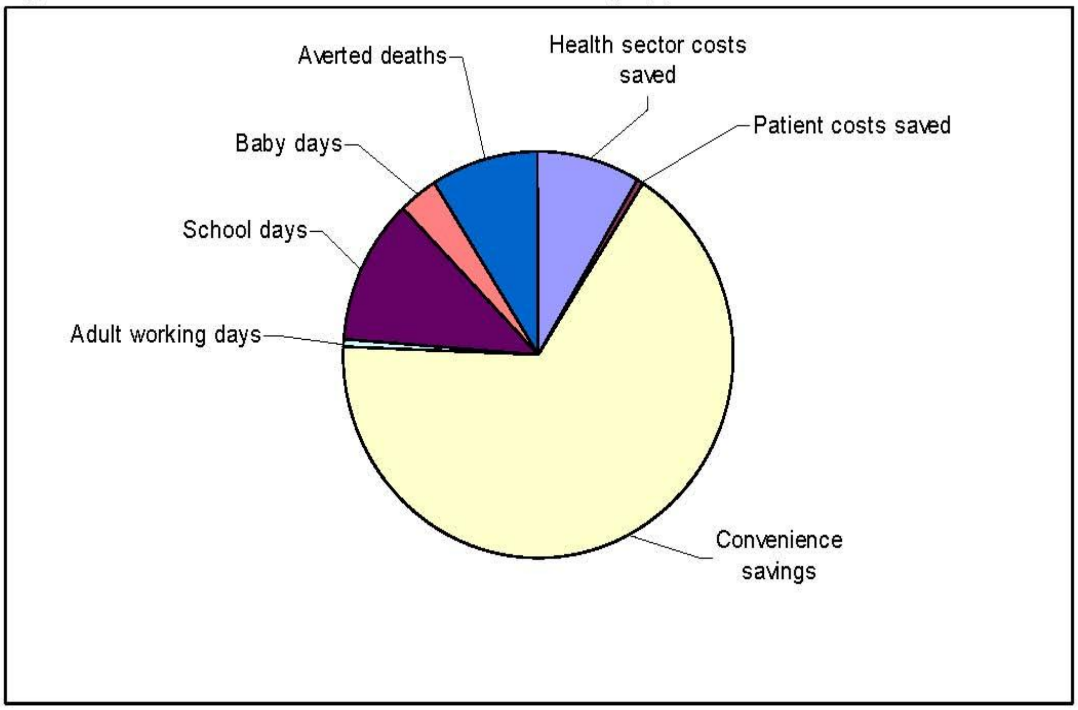
* For "high cost and low benefit" assumptions
§ Improved sanitation is defined here to include sewer connection, septic tank, pour-flush, pit latrine, or ventilated improved pit-latrine. Waste water treatment is not included as part of this definition.

The results in Table 4 suggest that benefits exceed costs for all of these interventions, except when pessimistic assumptions are made about both the costs and the benefits for intervention 5. Three observations deserve emphasis for our current purposes, however. The first observation is that a significant degree of progress has already been achieved in the LRB for these five improvements. Based on a National Survey of Household Living Conditions (UNDP 2004), for example, 72% of households use public networks for a source of potable water, and 46% use a public sewer network.

The second observation is that the majority of benefits for these interventions is due to time savings and productivity gains, rather than from direct health benefits, for example from reduced incidence of disease. The breakdown of these benefits is illustrated in figure 1, below, where we see that more than two-thirds of the benefits come from “convenience” savings, meaning the reduction in time and effort required to acquire water and dispose of wastes. Benefits related to avoided illness and related health care costs and lost productivity amount to no more than one-third of the total.

The third observation is that these improvements in water and sanitation do not address solid waste disposal or wastewater treatment. The delivery of piped potable water to households, and the connection of those households to public sewer networks, may be implemented without wastewater treatment. Indeed, this is the existing situation for many households in the LRB. Thus, this means that the evidence in Table 3 indicating that benefits exceed costs for many water-related investments, apply to investments with more direct, household benefits, and ones that these have largely been implemented already in the LRB.

Figure 2. Distribution of economic benefits by type of benefit



Source: Hutton and Haller, 2004.

Water pollution from domestic and industrial effluent can be very costly to downstream water uses, as indicated by studies in other countries. One study in Mexico (Margulis 1996) estimates that diarrheal diseases from water and solid waste pollution, lack of sanitation and foodstuff poisoning represented costs in terms of morbidity and mortality amounting to more than $3.6 billion annually. In another study for urban Delhi, India, health effects from polluted water were estimated to cost $4 million per year, or about $25 per person per year for the affected area (Dasgupta 2004). Increased illness from farming with polluted irrigation water has also been found to have significant ill health effects (Weldesilassie 2011).

3.2. COST OF REMEDIES FOR WATER POLLUTION

It is relatively easy to estimate the cost of controlling water pollution. The costs of constructing municipal wastewater treatment plants, and the operation and maintenance costs, are well-known, although some costs will vary from location to location, and for different scales of plants.[5] For a range of locations in the LRB, for example, the costs of wastewater treatment have been estimated to range from $11-17 per person per year in levelized (annualized) costs (USAID 2003). About two-thirds of these costs are for operation and maintenance, or between $7 and $11 per person per year. Cost of remediation for industrial pollution will vary considerably depending on the type of pollution. Costs for a range of improvements in water and sanitation are estimated in Table 3 above to vary from $0.30 to $22 per person per year depending on the service. Costs for solid waste collection and disposal are estimated to be $45-$50 per ton in Lebanon (SWEEPNET 2010). For per capita generation of solid waste volumes of 0.25 tons/year, this would be $14 per person per year.

3.3. WEIGHING BENEFITS AND COSTS

One of the central questions at issue for the LRB is: Do the benefits exceed the costs for implementation of public treatment of domestic wastewater, industrial pollution, and solid waste disposal? The WHO analysis (Hutton and Haller, 2004) does not address wastewater treatment directly or solid waste collection. Indeed, given the kinds of interventions the WHO analysis *does* address, and the importance of time savings in achieving those favorable benefit-cost ratios, the magnitude of additional benefits for wastewater treatment, and people's willingness-to-pay for those services, may be relatively small.

Indeed, in a recent meta-analysis that surveyed hundreds of existing economic valuation studies, Dale Whittington (2010) looked at a range of public services in developing countries and has identified a strong and consistent finding: these studies found a low willingness-to-pay for many kinds of services that were expected by outside observers to have a much higher value. Indeed, Whittington found that:

"In sector after sector, [survey] researchers found low willingness-to-pay for the good or service that was the focus of their study. WTP was low in absolute terms and as a percentage of income. Also, WTP estimates were low relative to the cost of service provision. … This conclusion is supported for (a) improved water infrastructure, (b) sanitation and sewerage, (c) household water treatment, (d) ecosystem services and watershed protection, (e) solid waste management and collection, (f) marine turtle

[5] Detailed analyses of the costs of many specific interventions can be found in the ELARD/UNDP report (2011).

conservation, (g) vaccines against cholera and typhoid infection, and (h) the preservation of cultural heritage assets."

Notice that the list of examples includes water treatment, ecosystem services and watershed production, as well as solid waste management and collection. Indeed, these are the goods and services frequently highlighted by government officials and other observers as problems for the LRB, and Whittington's observations suggest that the benefits of remediation may be perceived to be significantly higher by outside observers than by the households living in the LRB.

Some of the studies included in the Whittington survey address sewer connections and wastewater treatment. Some of these results in these studies are instructive for the current analysis. For example, Cloe et al. (1996) found that in the Philippines, among urban households in Davao City, Mindanao province, demand for sewer connections and municipal wastewater treatment was very low, at least an order of magnitude less than the costs of such services. At a cost of $1 per month, 37% of respondents rejected the idea of a management plan that would have provided households in their neighborhood with a connection to a sewer system and a municipal wastewater treatment facility to clean up the water pollution in the rivers and bay and to make the waters safe for recreational uses. Choe et al. concluded:

"People are aware of environmental problems [caused by poor urban sanitation], but water pollution control is simply not a high priority for residents of Davao. People do feel that they have lost valuable recreational opportunities as a result of water pollution, and many are concerned about possible food contamination. But these are not major problems in their lives compared to other pressing concerns. … Because households' willingness to pay for water quality improvements in Davao is much lower than the costs of providing such improvements, and because other environmental problems appear to deserve higher priority, the appropriate strategy in this case appears to be to wait until incomes are higher and willingness to pay has risen before embarking on a large investment program to control water pollution."

Of course, per capita incomes in the LRB are much higher than in the Philippines in the mid-1990s (perhaps three-times higher). Nevertheless, the general phenomenon of low willingness to pay for water quality improvements may be relevant to the LRB. Such a low willingness-to-pay by residents may exist either because the demand is still low, or because willingness to pay has risen relatively recently in Lebanon, but a policy response to those rising values has not yet materialized.

The potential effects of water pollution from domestic and industrial wastewater include many other effects beyond downstream health consequences or the effects on downstream irrigators. Often many other effects of water pollution and water misallocation are difficult to identify, measure and value. In response, a "total economic value" framework has been developed by economists to recognize all potential sources of value; this framework is applied to the LRB in the next section.

4. A WATERSHED'S TOTAL ECONOMIC VALUE

It is widely recognized that the value to society of a complex resource like a watershed is much greater than the values one could estimate for one or two specific services that are relatively easy to quantify. Thus, the concept of "total economic value" (TEV) has become an established and widely used framework to evaluate human-natural systems like watersheds. This TEV approach is based on the presumption that individuals will often hold multiple values (e.g., for a range of ecosystem services) associated with ecosystems, and it provides a basis for a taxonomy of the benefits associated with each type of value. Among the most useful aspects of this framework is that it ensures that all components of value are recognized in an empirical analysis (or even when framing discussions without explicit quantification), and also that double counting does not occur when multiple valuation methods are applied. The goal of TEV is not to ensure that a "total value" will always be estimated before a policy decision is made, but rather to alert the observer to the many ways in which marginal changes in ecosystem services can affect multiple values held by the same, or different, individuals. In other words, the framework ensures, as much as possible, that all relevant and potentially important values are counted or recognized when assessing the society's interests in a particular ecosystem (NRC 2004).

4.1. USE AND NON-USE VALUES

The TEV framework distinguishes between two types of value, "use value" and "nonuse value." Use value refers to the values associated with the direct use of an environmental resource by individuals; non-use value refers to values that do not involve directly using, or "using up", the resource – it continues to exist. Use value typically requires some interaction with the resource, but nonuse values do not require direct interaction (NRC 2004). The distinction can be illustrated as follows:

"Within the TEV framework an individual can hold both use and nonuse values for the services of an aquatic ecosystem. Consider an oil spill on a popular coastal beach resulting in forgone recreational trips to the beach—this is a lost use value. In addition, the oil spill could damage the ecosystem in ways that would not affect beach use and that beach users would never observe. It might, for example, kill marine mammals that live off the beach and are not seen by beach users, and beach users, as well as those who do not visit the beach, might experience a loss because of this ecosystem damage."(NRC 2004)

Table 5 presents general examples of use values (direct and indirect) and nonuse values. Table 6 presents more specific examples of some of the use and nonuse values that can be found to apply to a river basin or watershed like the LRB, where examples such as water storage, hydropower, fish, ecosystems and recreation are included. These categories represent the many ways in which a healthy watershed provides valuable ecosystem services in direct and indirect ways. Implicitly, it also suggests the damages or losses that arise when water system is polluted or degraded.

Table 5. Classification and Examples of Total Economic Values for Aquatic Ecosystem Services

Use Values		Nonuse Values
Direct	Indirect	Existence/Bequest Values
Commercial and recreational fishing	Nutrient retention and cycling	Cultural heritage
Aquaculture	Flood control	Resources for future generations
Transportation	Storm protection	Existence of charismatic species
Wild resources	Habitat function	Existence of wild places
Potable water	Shoreline and river bank stabilization	
Recreation		
Genetic material		
Scientific and educational opportunities		

Source: NRC 2004.

Table 6. Watershed Ecosystem Services and Examples of Indicators (From Smith 2006)

Watershed services	Service attributes	State indicator	Sustainable use indicator
Provisioning services			
Water supply	• Precipitation, infiltration, soil water retention, percolation, streamflow, groundwater flow • Biotic and abiotic effects on water quality	• Water storage capacity (m^3/m^2) • Pollutant concentrations	• Discharge (m^3/year)
Food provision	• Crop, fruit and livestock production • Edible plants and animals (e.g. fish, algae, invertebrates)	• Agricultural water use (m^3/ha) • Fish stock (kg/m^3)	• Maximum sustainable water use for irrigation (m^3/year) • Net Productivity (kg/ha/year)
Non-food goods	• Production of raw materials (e.g. timber, reeds) • Production of medicines	• Amounts available (kg/ha/year)	• Maximum sustainable harvest (kg/ha/year)
Hydroelectric power	• Flow for energy generation	• Storage capacity of riverbeds and lakes (m^3/km^2) • Slope (deg), elevation (m)	• Maximum sustainable energy production (kWh/year)
Regulating services			
Regulation of water flows	• Retention of rainfall and release (especially by forests and wetlands) • Water storage by rivers, lakes and wetlands • Groundwater recharge and discharge	• Infiltration capacity (mm/h) • Water storage capacity of soils (m^3/m^3)	• Baseflow volume (m^3/year);
Hazard mitigation	• Reduced flood peaks and storm damage • Coastal protection • Slope stability	• Maximum natural water storage capacity (m^3/m^2)	• Size (km^2) and economic value (US$/$km^2$/year) area protected from flooding
Control of soil erosion and sedimentation	• Protection of soil by vegetation and soil biota	• Infiltration capacity (mm/h) • Slope length (m) • Barren land (%)	• Soil loss (kg/ha/year) • Sediment storage (kg/ha/year)
Water purification	• Reduced siltation of streams and lakes • Nutrient uptake and release by ecosystems • Removal or breakdown of organic matter, salts and pollutants.	• Nitrogen amount (kg/ha) • Total dissolved solids (kg/m^3) • Electric conductivity (μS/cm)	• Denitrification (kg/ha/year)
Supporting services			
Wildlife habitat	• Wildlife and nursery habitats	• Resident and endemic species (number) • Surface area per ecosystem type (ha)	• Increase or decline in species population size (number)
Environmental Flows	• Maintenance of river flow regime	• Area of critical habitats (ha) • Discharge for each season (m^3/day)	• Fish species and population • Total fish catch (t/year)
Cultural & amenity services			
Aesthetic and recreational services	• Landscape quality and features	• Stated appreciation • Recreational value (e.g. entrance fees (US$/visit)	• Houses on lakeshore (number/km) • Visitors (number/year)
Heritage and identity	• Landscape features or species	• Cultural significance and sense of belonging	• Visitors (number/year) • Pilgrims (number/year)
Spiritual and artistic inspiration	• Inspirational value of landscape features and species	• Books and paintings using watershed as inspiration	

4.2. QUANTIFYING ECONOMIC VALUES OF WATERSHEDS

Quantifying these values for a particular ecosystem can be a daunting and resource-intensive challenge. Numerous case studies can be found where some, but not all, of the recognized ecosystem services have been estimated in economic terms. In a recent study, Smith et al. (2006) summarize results from an attempt to estimate upper and lower bounds for a range of ecosystem services for both developed and developing economy contexts (see Table 7). The values are estimated on a $/ha/year basis, and these will no doubt differ greatly depending on the population that resides in, or depends on, the watershed.

Table 7 - Estimates of economic values of watershed ecosystems services

	Developed economies ($/ha/year)		Developing economies ($/ha/year)		Developing economy values applied to LRB ($ million/year)	
	Low	High	Low	High	Low	High
Provisioning services						
Water for people	45	7500	50	400	12.3	98.4
Fish/shrimp/crabs	200		6	750	1.5	184.5
Agriculture & grazing	40	520	3	370	0.7	91.0
Wildlife (for food)	40	520	0.02	320	0.00	78.7
Vegetables & fruits	40	470	1	200	0.2	49.2
Fiber/organic raw materials	45		1	40	0.2	9.8
Medicinal plants			6	6	1.5	1.5
Inorganic raw materials	15	160	0.1	0.1	0.0	0.0
Regulating services						
Water quality control	60	6700	20	1400	4.9	344.4
Flood mitigation	15	5500	2	1700	0.5	418.2
Groundwater replentishment			10	90	2.5	22.1
Erosion control			20	120	4.9	29.5
Carbon sequestration	130	270	2	2000	0.5	492.0
Microclimate stabilization			10	10	2.5	2.5
Supporting services						
Biodiversity conservation			0.6	3600	0.1	885.6
Cultural and amenity services						
Recreation & tourism	230	3000	20	260	4.9	64.0
Cultural/regilious activities	30	1800	80		19.7	19.7
Total ($ millions)					$ 57	$ 2,791

Source: Smith, M., de Groot, D., Perrot-Maitre D. and Bergkamp, G. 2006. Pay: Establishing payments for watershed services . Gland, Switzerland, IUCN, World Conservation Union. Adapted from Korsgaard, L. 2006. Quantification of Environmental Flows in Integrated Water Management. PhD Thesis. Institute of Environment and Resources, Technical University of Denmark.

Indeed, the estimates presented in Table 7 should be interpreted as "suggestive" of the range of values that might be found in most watersheds, rather than as accurate upper and lower bounds. With this caveat, however, the results in Table 7 offer a number of insights that are relevant for the LRB. First, the range of economic values derived from any given ecosystem service can vary enormously. For example, an unpopulated watershed will not generate much value in terms of "water for people." Water quality control benefits can vary by a factor of 10 or 100. The largest values in developing countries tend to come from a) water for people, b) fish and shellfish, c) water quality control, d) flood mitigation, e) carbon sequestration, and f) biodiversity conservation. In developing countries, fish/shellfish values and carbon sequestration tend to be lower, while recreation and tourism tend to be higher. Also, agriculture does not stand out as a dominant source of value for watersheds, and hydropower was not included in this analysis.

4.3. ECONOMIC VALUES FOR ECOSYSTEM SERVICES IN THE LRB

When the values in Table 7 for "developing economies" are applied to the LRB, the range of values for agriculture ($0.7 –$ 91 million) include the $17 to $23 million estimate computed above. The low end of the range of total values, $57 million, is exceeded by the calculations above for agriculture and hydropower alone. Water for people may be one of the more reliable ranges, indicating $12 to $98 million for the LRB. But, perhaps the most useful insight from this table is that for both low and high estimates, more than three-quarters of the estimated value for watersheds comes not from the relatively easy-to-measure services such as agriculture and water for people, but from difficult to measure ecosystem services such as water quality control, flood migration, biodiversity conservation, and (potentially) carbon sequestration. If we assume that these same relative magnitudes hold for the LRB, it suggests that the total economic value could easily exceed $500 million annually.

It is also instructive to look at how some of the ranges of values change between developing economies and developed economies. In the case of recreation and tourism, for example, both ends of the range of values suggest a 50 fold increase between a developing economy and a developed economy. Given the presence of significant recreational activity in the LRB (resorts, springs, wineries, fishing, lake recreation), these estimates underscore the potential current and future benefits of making the entire LRB more appealing for recreation and tourism (remediation of uncontrolled water pollution and garbage disposal that creates smells, dis-amenities, and health concerns). These improvements could, potentially, have high payoffs in terms of increased investment in tourism and recreation, although the value of these potential benefits is highly uncertain.

5. TOTAL ECONOMIC VALUE AND ECONOMIC DEVELOPMENT

The previous discussions of total economic value involve stepping back and taking a more holistic view of the value of a watershed, including its many interconnected ecosystem services that contribute in diverse ways to society's standard of living and wellbeing. It is now well understood that natural resources such as those contained in a watershed provides a wide range of ecosystem services that contribute in direct and indirect ways not only to current standards of living but also to economic growth and development. Some resources contribute directly to the population's income, and this in turn generates savings and investments that contribute to growth. In other cases, the relationship between a landscape's total economic value and growth in a dynamic economy are indirect and more difficult to measure, such as the environmental amenities that attract visitors for recreation and tourism, but they can be equally important.

Moreover, there is strong evidence from other regions and countries of patterns of growth and development involving national investments not only in public goods such as education and social services, but also in environmental protection and remedies for pollution. Government interventions are initiated to remedy environmental pollution and degradation problems in order to protect these resources. For the most part, these investments and policy choices have been made based, not on comprehensive and explicit calculations of total economic value, but rather with a collective view or determination that the benefits of these remedies outweighed the costs, and that protection of the full complement of services provided by watersheds needed to be protected and managed for the benefit of society as a whole.

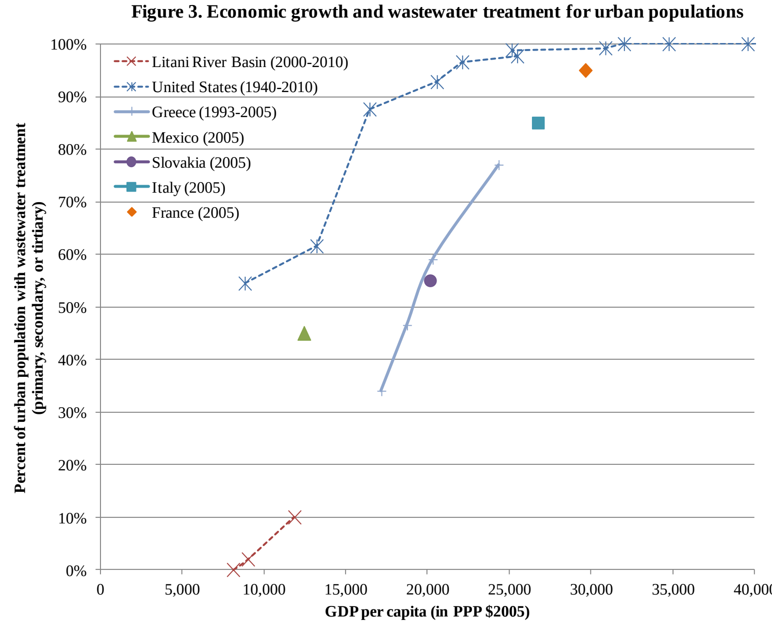
Based on these kinds of investments and policy choices made in many other countries, we can ask, at what stage of development, or, more concretely, at what level of per capita income, have nations tended to make the public investments necessary to protect their watersheds from high levels of raw sewage and other pollutants? And what implications do those trajectories for other countries have when compared to the trajectory in the LRB?

Although comprehensive data are not available, some indicators can be assembled to provide an indication of the patterns that have emerged across a range of countries as their incomes have risen. Figure 3 shows the share of the population served by wastewater treatment for a range of countries and the LRB, and across a range of levels of income per capita (normalized to reflect 2005 US dollars converted using Purchasing Power Parity exchange rates). These data involve different time periods for different countries, because we are most interested in looking at the relationship between income per capita and the share of the population served by wastewater treatment plants. If we assume that nations are basing these investment decisions on a conclusion that the benefits exceed the costs, then the question becomes: At what level of income does it appear that most countries have concluded that the benefits exceed the costs for providing their population with municipal waste water treatment?

As Figure 3 suggests, by the time income levels reach $15,000 per capita, countries have already made municipal wastewater treatment services available to about half their population. Moreover, as incomes rise from that level to $25,000 per capita, the share of the population served tends to rise to more than 90%. This pattern has been observed in countries as diverse as the US, Greece and western European countries. By contrast, the LRB, with an income per capital level of about $12,000 per capita (Laithy, et al., 2008), provides wastewater treatment services to no more than 10% of its population – indeed there were no wastewater treatment plants in the region in 2000 (SPI-Water 2007).

Thus, this suggests that Lebanon is "late" to make these kinds of investments in comparison to other countries at similar stages of growth in per capita income.

Figure 3. Economic growth and wastewater treatment for urban populations



Sources: OECD (2008), EPA (2000), ELARD/UNDP 2011.

6. THE ROLE OF INSTITUTIONAL CAPACITY

The third of the three main factors mentioned above as being responsible for the water pollution problems in the LRB is limited institutional capacity. In general, economists argue that market failures due to externalities and the undersupply of public goods can be corrected by "internalizing" the external costs, that is, through public provision of remedies (wastewater treatment), or with the provision of public infrastructure (irrigation canals and support services). But the provision of public infrastructure and services, as well as the monitoring and enforcement of property rights, requires effective institutions – laws and regulations and procedures that are necessary complements to a healthy market economy (North 1990). Indeed, an efficient allocation of resources for a natural-human system such as a watershed or other ecosystem will always require a mix of institutions at local, regional and national levels, with the complementarities among some or all of the following: private property rights, markets, government laws and regulations, common pool resource management systems, effective monitoring and enforcement, both formal and informal (Jaeger 2005).

An economic analysis can identify situations where resources are misallocated or where pollution damages are greater than the costs of remediation. But the conclusion that a remedy should be promoted will depend, at least in part, on the judgment that changes in laws, regulations, or public infrastructure will be managed, monitored and enforced in such a way that the expected benefits can be realized. If existing institutions are not up to that task, then the limiting factor or "binding constraint" precluding efficient use of water resources may not be the absence of laws prohibiting polluting, or wastewater treatment infrastructure, but rather the absence of effective management and political institutions under which the laws, regulations and public investments are implemented and enforced.

Given the importance of institutions to guide resource use, public investments, and monitoring and enforcement, as well as processes for anticipating changes in resource needs, and adjusting rules and public investments to respond to those changes, the institutional environment is critical for providing an "enabling environment" in which improvements in water resource management can be promoted. There is clear evidence that significant institutional obstacles exist in Lebanon and in the LRB in particular. In particular, in a review of Lebanon's water sector expenditures, the World Bank (2010) found significant institutional weaknesses related to institutional uncertainty about sector responsibilities, a lack of integration and inter-agency coordination, inadequate regulatory instruments for effective oversight, and limited management and financial autonomy for the Regional Water Authorities (World Bank 2010). Similar institutional constraints are evident in other recent reports (see, for example, Svendsen 2010; ELARD 2011). Thus, the overall situation in the LRB appears to be one where a lack of effective institutions represents a sizable obstacle blocking a variety of policy recommendations that might otherwise promote more efficient use of water resources in the LRB.

7. CONCLUDING COMMENTS

It is clear that the water resources in the Litani River Basin could be better managed to serve the interests of the people of Lebanon. Specific prescriptions require further careful and detailed analysis before choosing a course of action. The economic analysis presented here supports some general conclusions, and also points in directions needing further study.

First, the water resources in the LRB used for irrigation, hydropower, household, and industrial uses provide services worth between $75 million and $120 million annually. Moreover, one can confidently assume that if the all ecosystem services in the watershed could be accurately valued, their total economic value (TEV) would be many times larger than this. Thus, combined with continued growth in demand for water and water-related ecosystem services in the LRB, these findings suggest a need increased attention to improving both water use efficiency and water quality, as well as consideration of additional seasonal water storage.

Second, agriculture is one of the most important uses of water in the LRB. Some evidence suggests that agriculture could make better use of the water resources available for irrigation. Some farmers "over-irrigate" or could conserve water by adopting drip irrigation. Irrigators in some cases use excess water to irrigate, water that otherwise could be put to good use irrigating additional lands. For example, conserving 20% of water used in irrigation could provide for an additional $2 million of value-added in agriculture. Thus, additional study of how irrigation water is currently being used, as well as investigation into the technical and economic efficiency of irrigation management should be high priorities.

Third, significant water quality problems exist in Lebanon and in the LRB. Indeed, a recent World Bank report (2010) recently concluded that the "state of the water supply and sanitation sector in Lebanon is

not in line with the level of economic development reached by the country." Regional Water Authorities underperform, in part due to underfunding. Water losses in these systems are high; the World Bank (2010) reports that the collective water efficiency in the Bekaa Water Authority is 11 percent.
The development of effective waste water treatment systems is still in an embryonic stage in the LRB, with few plants in operation. This water quality situation in the LRB is particularly noteworthy because the Litani River is the largest, most important river basin in a country that is classified by the World Bank as "upper middle income." As noted above, residents in the upper parts of the basin may have a low willingness-to-pay for wastewater treatment because of the incentive "free rider" problems associated with externalities. Nevertheless, for Lebanon as a whole, these water pollution and solid waste disposal problems seem incongruous with the standards found in other countries with similar levels of per capita income. Indeed, the LRB is a region where half of households own at least one car, where half of households own an automatic washing machine, and where one-third possess a cell phone. Yet the Litani River continues to be used as an open sewer and dump site, rather than being protected as a valued natural resource for the nation.

Given the very low levels of wastewater treatment for domestic and industrial effluent, the available evidence suggests that the LRB's ecosystem services and "total economic value" have been significantly degraded in ways that adversely affect the local population, the nation as a whole, as well as their future prosperity.

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